

The Grid and Power Station Operation

Introduction

This document gives a brief introduction into: how the grid operates; how demand and supply are balanced; how power stations are operated and how renewable energy interacts with this.

Overview

Electricity can not be efficiently stored, therefore all the power stations in the UK are connected via the National Grid ('Transmission System'). As demand for electricity changes, power stations are turned on and off and their outputs changed. Nuclear and the most efficient fossil fuel stations are operated when demand is low with less efficient (dirtier) stations being when demand is high (as they cost more in fuel to run).

Balancing demand and supply

Demand for electricity varies continuously and by a very large margin. Demand must be met exactly by generation or the grid voltage and frequency drop and the grid 'collapses' i.e. goes off. When demand increases, output from power stations is increased and if the change in demand is large additional power stations are started.

Station operation is planned up to 24 hours in advance, coal stations can take up to 4 hours to heat-up and nuclear stations can not be easily turned off. To meet changes in demand some power stations are run 'part-loaded' i.e. below full output. This causes them to be less efficient and therefore dirtier.

Electricity is sold between one year and one hour ahead of delivery with nuclear and the more efficient fossil fuel stations being used continuously with less efficient stations being operated during times of peak demand. Therefore Gas stations are more efficient (and cleaner) than coal but burn a more expensive fuel, therefore whether coal or gas is used is mainly determined by fuel prices.

It is possible to change demand by asking large users (e.g. water works) to disconnect during periods of high demand. There is potential for many more users (including houses if they were fitted with 'smart' meters) to reduce demand when asked e.g. turn off washing machines. Reducing peaks in demand would mean that less efficient stations would not be required to operate.

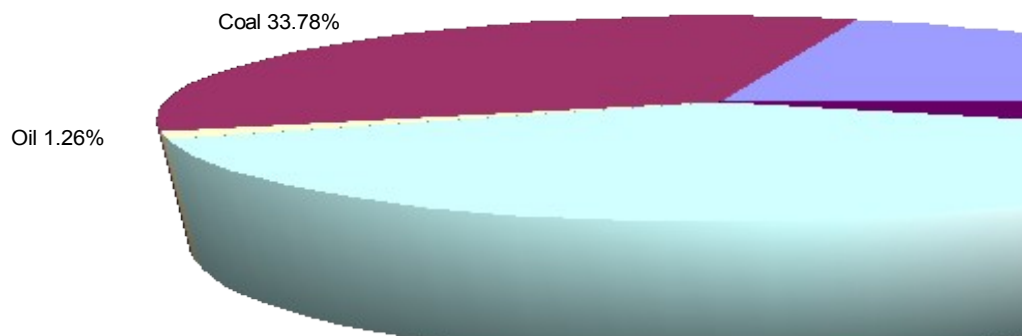
The Grid

At present electricity can not currently be efficiently or cost-effectively stored. Each city used to have its own power station and local grid. This was inefficient as the station had to be run below full capacity to be able to meet changes in demand during the day. The construction of a National Grid (Transmission System) between cities and power stations enabled coal to be burnt near the coal fields in the north (Yorkshire and East Midlands) and the electricity (rather than the coal) to be transported to the south of England. The grid has also meant that only a small number of stations have to run at part load to meet changes in demand. Nearly 10% of electricity generated is lost during transmission and most of this is during transformation to distribution voltages.

The grid is owned and operated by National Grid Plc who became a public listed company in the 1990s. National Grid is a monopoly regulated by the Government (Ofgem).

Power Station Operation

Since the privatisation of electricity generation the construction and operation of power stations has been performed by private companies. It is worth noting that all older (pre 1990s) power stations were built by the state e.g. the old Central Electricity Generating Board built the coal stations and what is now British Energy built nuclear stations). This means that these stations haven't paid for the cost of building the station; they only pay for fuel. Therefore it is hard for new stations (such as wind) to compete as they have to pay the full cost of construction.



Most of the “Renewables & other” section comes from burning biomass / waste but includes large hydro - 1% and wind - 0.5%.

Coal Power Stations

Coal produces the most CO₂ per unit of electricity i.e. it is the dirtiest source of electricity. For each unit of energy generated by burning only around one third is converted to electricity. The rest is lost as waste heat. The use of coal has been growing since 2000 due to increasing gas prices and rising demand for electricity. Prior to 2000 gas was used as much as possible due to low prices (we were burning the North Sea reserves).

Some time ago the EU introduced Large Combustion Plant Directive in order to reduce acid rain causing nitrous oxides. This means that stations have to choose to stop operating by 2008 or install expensive stack cleaning equipment (scrubbers). After years of trying to bend the laws and threatening to stop operating, most stations are now going to install the scrubbers. Drax already has the equipment installed. Drax is by far the largest station in the country as it is effectively two adjacent power stations. Drax could provide nearly 10% of the country’s electricity; equivalent to 4,000 100m wind turbines (in windy places!).

Coal stations (including Drax) currently burns small amounts (less than 8%) of biomass. The biomass mainly consists of palm-oil kernels and olive-husks from overseas but also includes locally grown coppiced willow. Drax burn this biomass as the electricity generated is classed as renewable and is worth extra money. Burning biomass reduces CO₂ output from the station. Most of the coal burnt at Drax is imported and worldwide coal supplies are expected to last hundreds of years.

Many (including the government) are keen to continue using coal but capture the CO₂ and pump it under the ocean into oil fields (sequestration). Pumping CO₂ into old oil fields allows more oil to be extracted and is already done in Norway and the US. Pumping CO₂ under the ocean requires energy (and therefore money) and creates a pollution problem, the impact of which is unclear.

Renewable Energy

Most renewable electricity generators are not connected to the transmission network but are connected to the local ‘Distribution Network’ (smaller pylons which supplies power to towns and houses). The grid has been designed for power to flow from power stations via the transmission system through the Distribution System to houses. Renewable energy generation can cause power to flow the opposite way (from the distribution system to transmission system); this can raise serious technical problems. The power from renewable power stations such as wind can not be controlled like a coal /gas power station (which change power via fuel supply). Changes in output from wind is balanced by ‘part loaded’ plant.

The National Grid has stated that the grid could “readily” cope with 10% of electricity from wind. Currently less than one percent of our electricity comes from wind energy.

References:

<http://www.parliament.uk/post/pn163.pdf>,

<http://www.dti.gov.uk/energy/statistics/source/electricity/page18527.html>